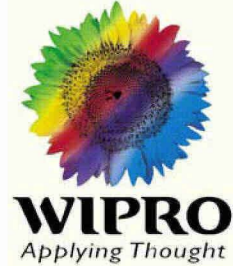


EXHIBIT 16



Network infrastructure for IPTV

Date: 24 Jan 2006

Presenter: Saisree Subramanian



Agenda

- What is IPTV
- Market trends
- Network infrastructure
- How IPTV services work
- Case study on deployment
- Challenges



What is IPTV?

IPTV is not TV that is broadcast over the Internet!

*“The **secure and reliable delivery** to subscribers of entertainment video and related services. These services may include, for example, Live TV, Video On Demand (VOD) and Interactive TV (iTV). These services are delivered across an **access-agnostic, packet-switched network** that employs the **IP protocol** to transport the audio, video and control signals. In contrast to video over the public Internet, with IPTV deployments, network security and performance are **tightly managed** to ensure a **superior entertainment experience**, resulting in a compelling business environment for content providers, advertisers and customers alike”.*

(Source Alliance for Telecommunications Industry Standards' (ATIS) IPTV Exploratory Group)



Service offerings with IPTV

- Broadcast TV (subscription based)
- Video on Demand
- EPG (Electronic Program Guide)
- Multi-room access
- DVR (Digital video recording)
- Photo sharing/video sharing
- Additional bundling
 - Music services (audio)
 - Voice services (VOIP with add-on services like call forwarding, caller id etc.)
 - Data services (internet access)
 - Messaging services

Focus is on “Quality of User Experience”



Analyst viewpoint



Market info – IPTV Equipment & Services

- Worldwide IPTV service revenue will grow to over \$44 billion in 2009
- IPTV services infrastructure capex will grow 1,377%, from \$304 million to close to \$4.5 billion as providers look to IPTV services as the means of raising ARPU from a near-saturated broadband subscriber base
- The number of IPTV subscribers worldwide will grow to 53.7 million in 2009
- IPTV subscriber growth is strong in all regions, especially in Asia Pacific, where faster forms of DSL like VDSL and ADSL2/2+ are stimulating subscriber growth
- The number of IPTV subscribers in North America will increase 12,985% between 2004 and 2009
- DSL providers account for the bulk of IPTV service revenue now, but **cable broadband** providers will also migrate to all-IP triple-play services in the next few years, possibly offering wireless services as well

"Service providers have been investing in IP DSLAMs, broadband edge routers, and aggregation switches to prepare for IPTV in the network infrastructure layer, but are having to make significant investments in the services layer too, adding video on demand servers, encoders, and headend equipment as well. But the biggest decision they face right now is **who to choose as a middleware partner**."

- Richard Webb, Directing Analyst, Wireless Broadband & Mobile, Infonetics Research (lead author of the report)

Source: Report published by Infonetics Research Inc dated 15 Nov 2005

Technical requirements on infrastructure providers for delivery of IPTV

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- Reliable access connectivity with assured bandwidth
- Sufficient metro bandwidth to support continuous streaming traffic
- Support for both unicast & multicast traffic
- Intervention ability for authentication & authorization
- Adequate accounting support for different services
- Ensuring secure transmission which cannot be tapped by non-subscribers
- Possibility of traffic prioritization and policing at the edge

The provider must support IPTV service delivery platforms

Why is this different from traditional data services?

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- Continuous stream with no fluctuations for the duration of the stream
- With a broadcast offering, a large number of customers will be simultaneously using the service
 - Overprovisioning access bandwidth may not work well
- Caching mechanisms assume importance and there are increased buffer requirements to allay problems due to packetization – packet loss, delay, jitter
- Multiple multicast streams with varying usage patterns

Engineering the network for video is a non-trivial problem and requires understanding of IP networking as well as video services.



Applicable standards

- ATIS IIF (IPTV interoperability forum) formed in mid-2005 and chartered to standardize IPTV usage by telcos in US
 - 4 task forces – Architecture (ARCH), Digital Rights Management (DRM), Quality of Service and Metrics (QoS), and Testing and Interoperability (T&I)
 - Over 70 participating organizations – both service providers and TEMs.
- China specific IPTV standards being defined by Ministry of Information Industry and the state administration of Radio, Film and Television – first release expected in early 2006
- TMF catalyst project on IPTV FAB for TMW (Nice 2006)
- Video encoding standards – MPEG1, MPEG2, MPEG4 (from MPEG industries forum), H.264 (from ITU)
- TV standards – HDTV and SDTV (from Consumer Electronic Association)
- Streaming protocols – RTP, RTSP (from IETF)
- IP Multicast – IGMP (from IETF)
- QoS – Diffserv/MPLS/802.1p (from IETF/IEEE)



Existing datacom infrastructure & the impact of IPTV





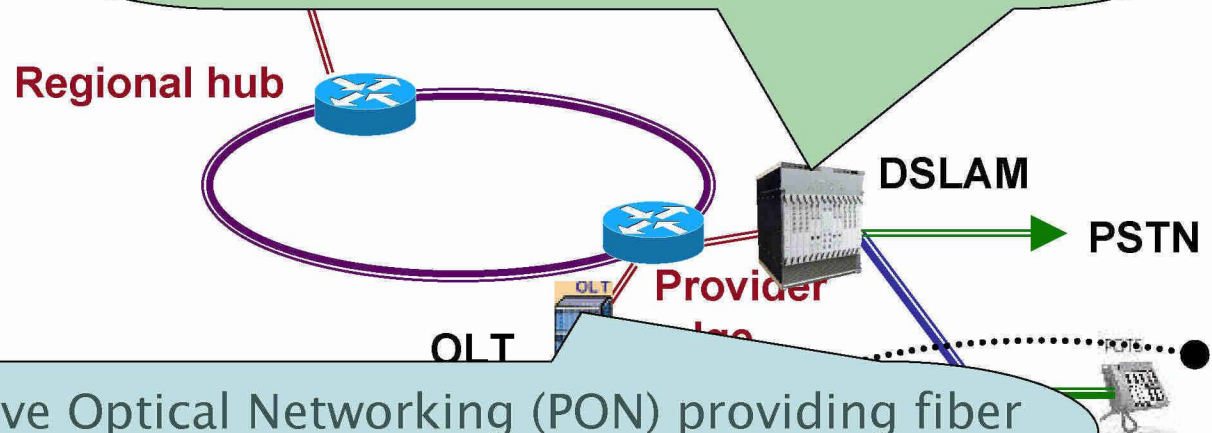
Current data network infrastructure

- DSL variants – ADSL, ADSL2+, VDSL
- Gigabit Ethernet
- Ethernet link aggregation/priority/VLAN/VLAN stacking
- IGMP & IGMP snooping
- PIM-SM
- BRAS features (or co-located with BRAS)

Regional hub

Considering prevalent wireline access technologies. Model is extended to WLAN and WiMAX.

- Passive Optical Networking (PON) providing fiber to the premises/node/kerb
 - Distinction is on how near the customer fiber is available (rest over copper (ie) DSL)
- Multiple PON standards – APON (ATM encapsulation), EPON (Ethernet encapsulation), GPON (combination)





Notes on bandwidth requirements

Metro bandwidth requirements for 1000 users:

- 50 SDTV channels => 175 Mb
- 10 HDTV channels => 190 Mb
- 1000 VOD users @ 3.5 mbps => 3500 Mb
- Non-video traffic => 1000 Mb

Total 5 Gbps!

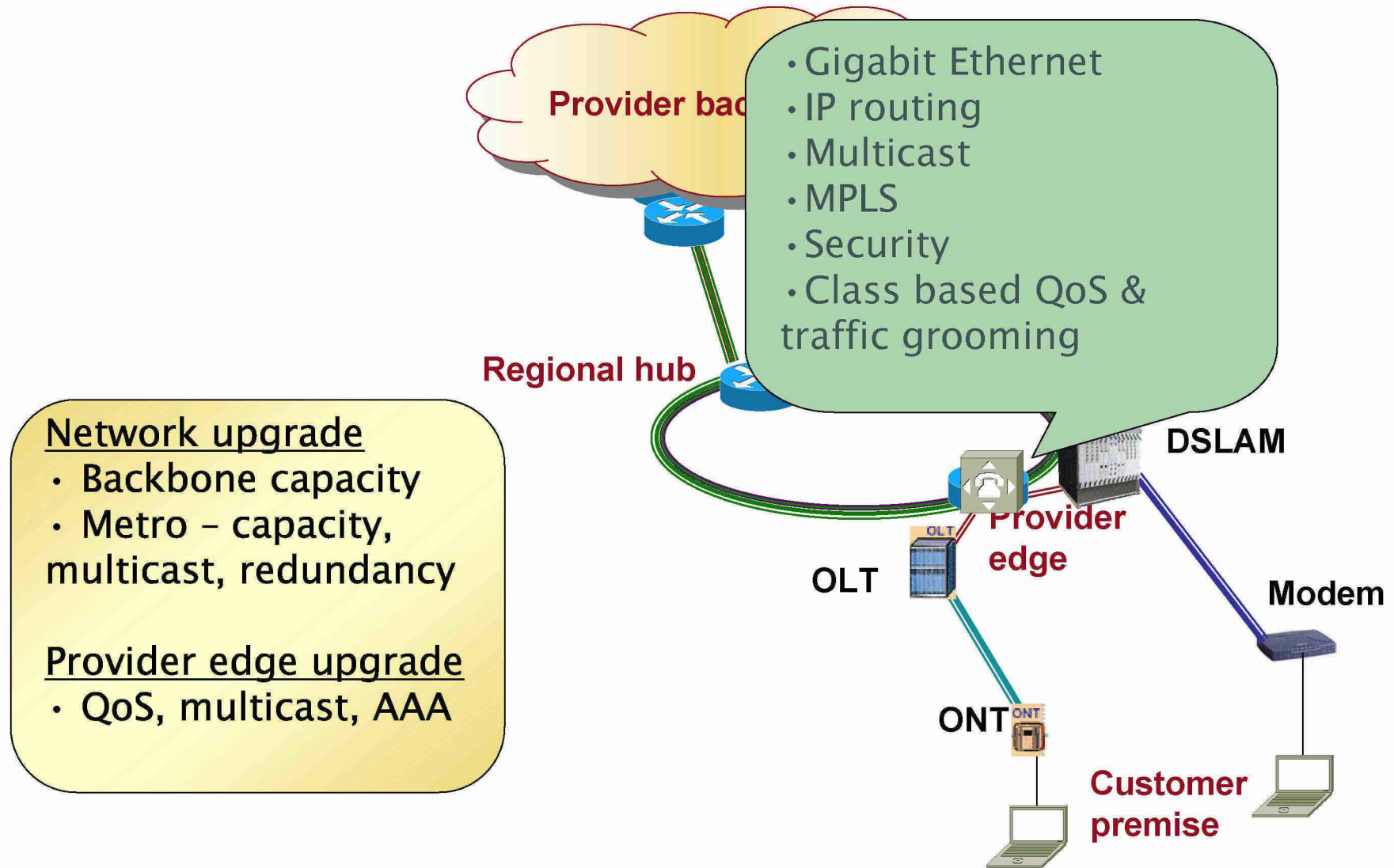
	BW for MPEG2	BW for MPEG4
SDTV	3.5 mbps	1.5 mbps
HDTV	19 mbps	8 mbps

Last mile access bandwidth requirements per user:

- 1 SDTV channel => 3.5 Mb
- High Speed Internet => 1 Mb

Total 4.5 Mbps!

Upgrades to existing data network infrastructure





Addition of video

Content protection

- Encryption – protection of stored and transmitted video
- Digital Rights Management (DRM)
- Implemented at headend as well as STB
- Dynamic algorithm change may be supported for some specific content

Systems

systems
multiple
requests
requests in

Broadcast
Acquiring
feed and

point to point mode

- Distributed architectures
- Scalability with
- Intelligent re-routing of
- Content

IPTV middleware:

- Responsible for the on-screen experience
- Electronic program guide (EPG) – covering broadcast and on-demand content
- Subscriber management system (SMS)
- Content management and packaging including promos & trailers as well as advts.
- Content rating and pricing
- Audit trail and reporting functions
- Business support system (BSS) interfaces – ex. billing and payment functions

Provider
age

Modem

STB

Customer
premise

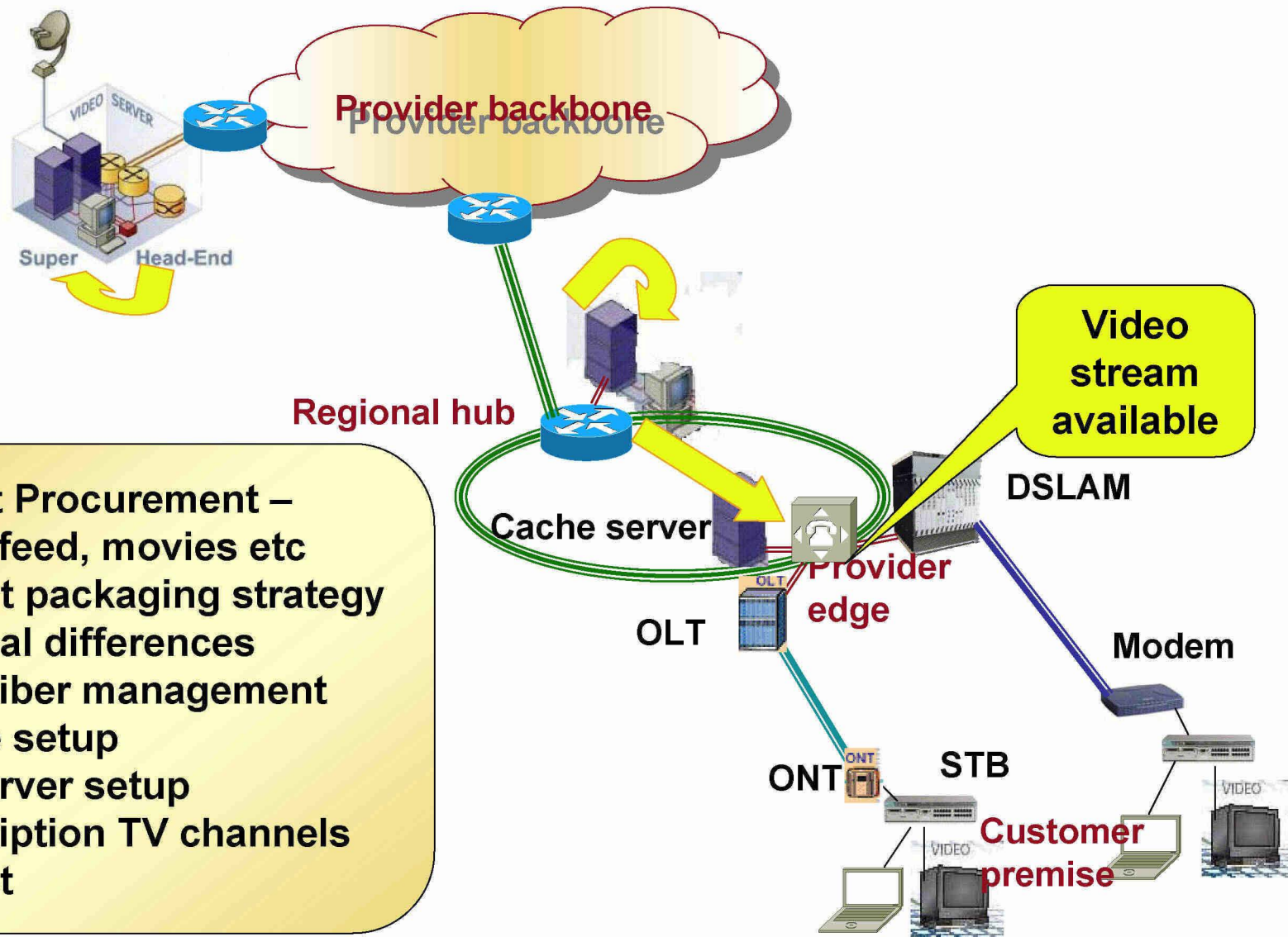
etc



How does it actually work?

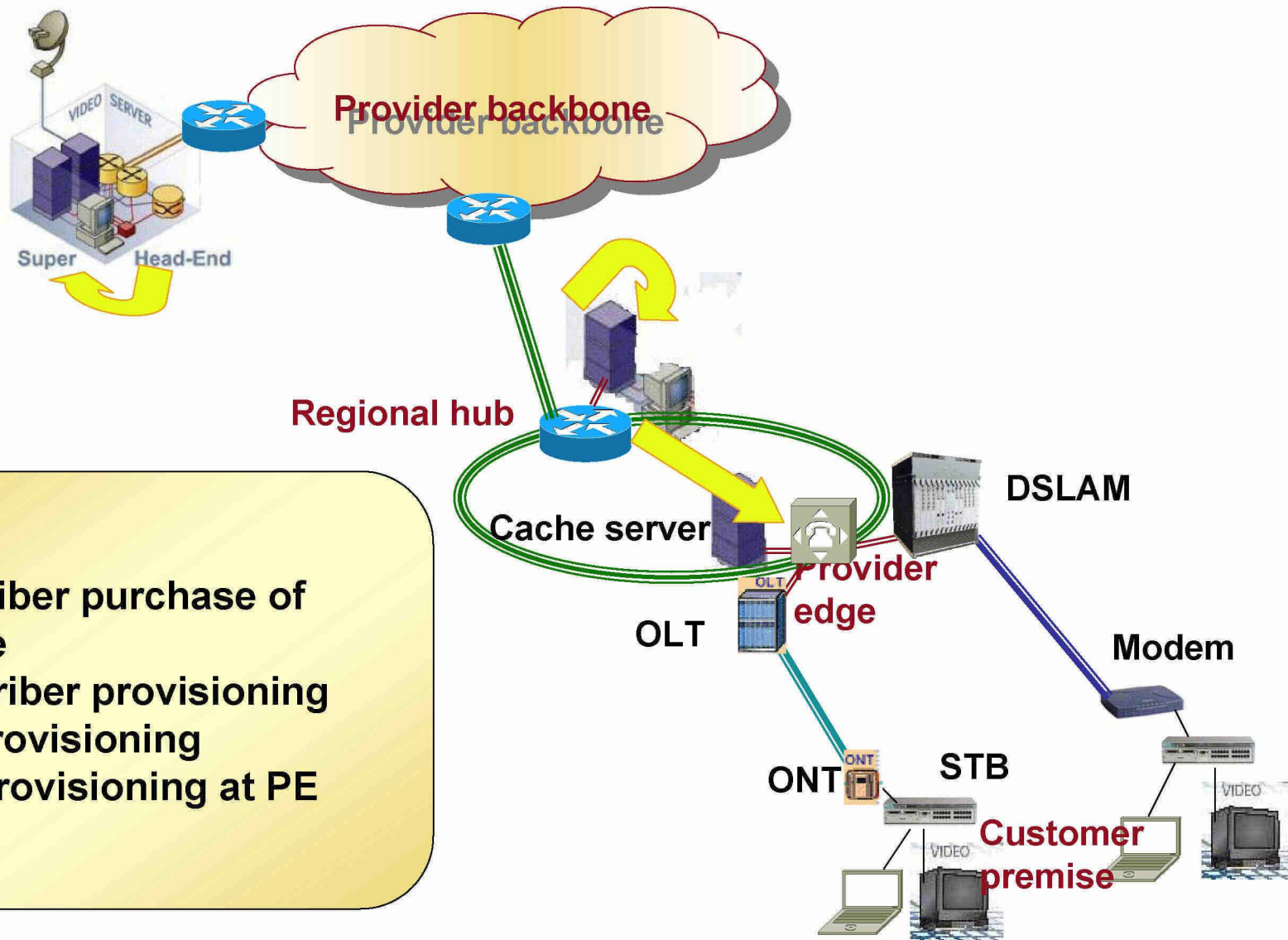
- Pre-requisite – network infrastructure upgrades complete

Step 1: Service provisioning by provider



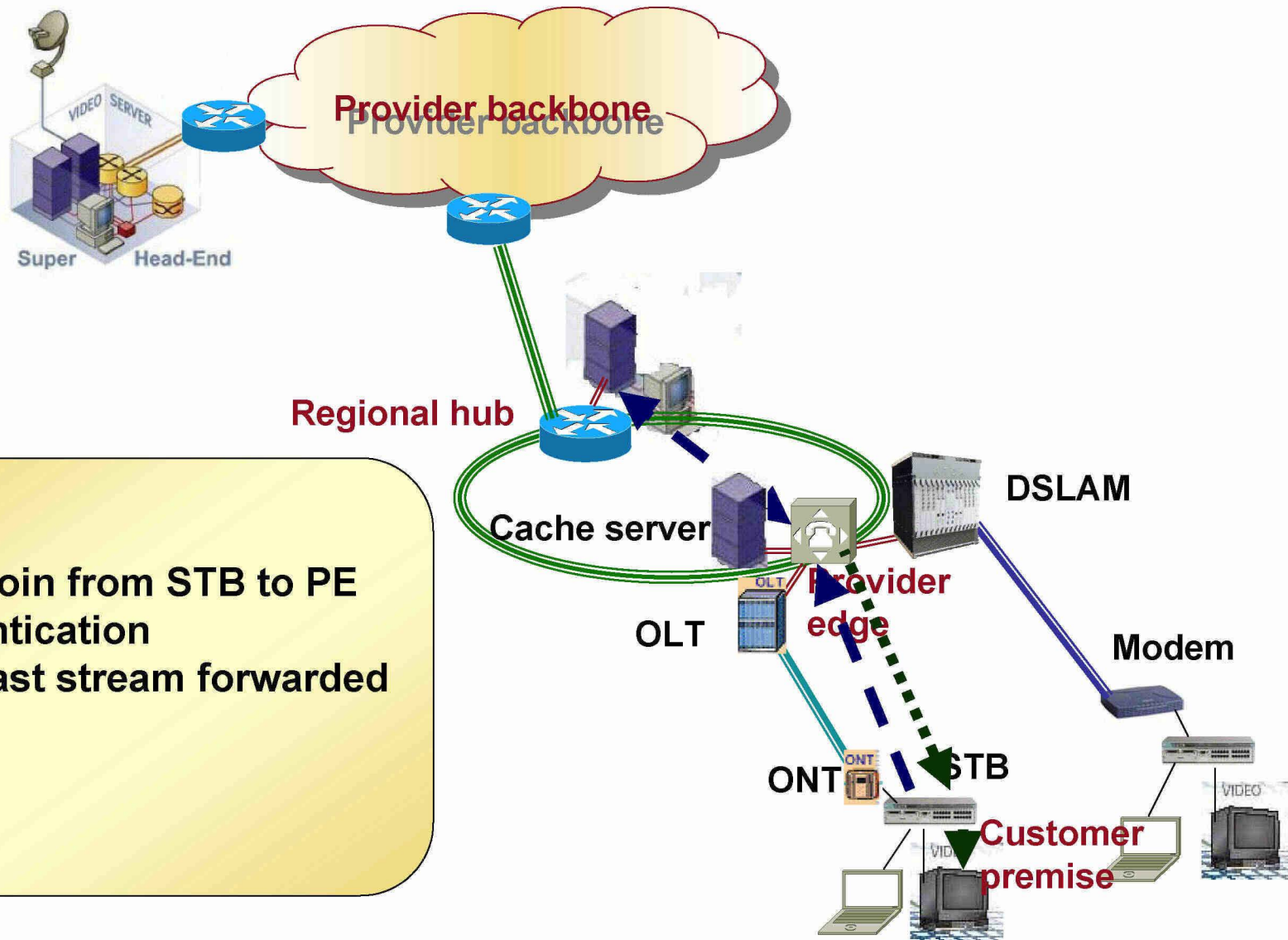
- Content Procurement – satellite feed, movies etc
- Content packaging strategy & regional differences
- Subscriber management software setup
- VoD server setup
- Subscription TV channels multicast

Step 2: Customer opting for service



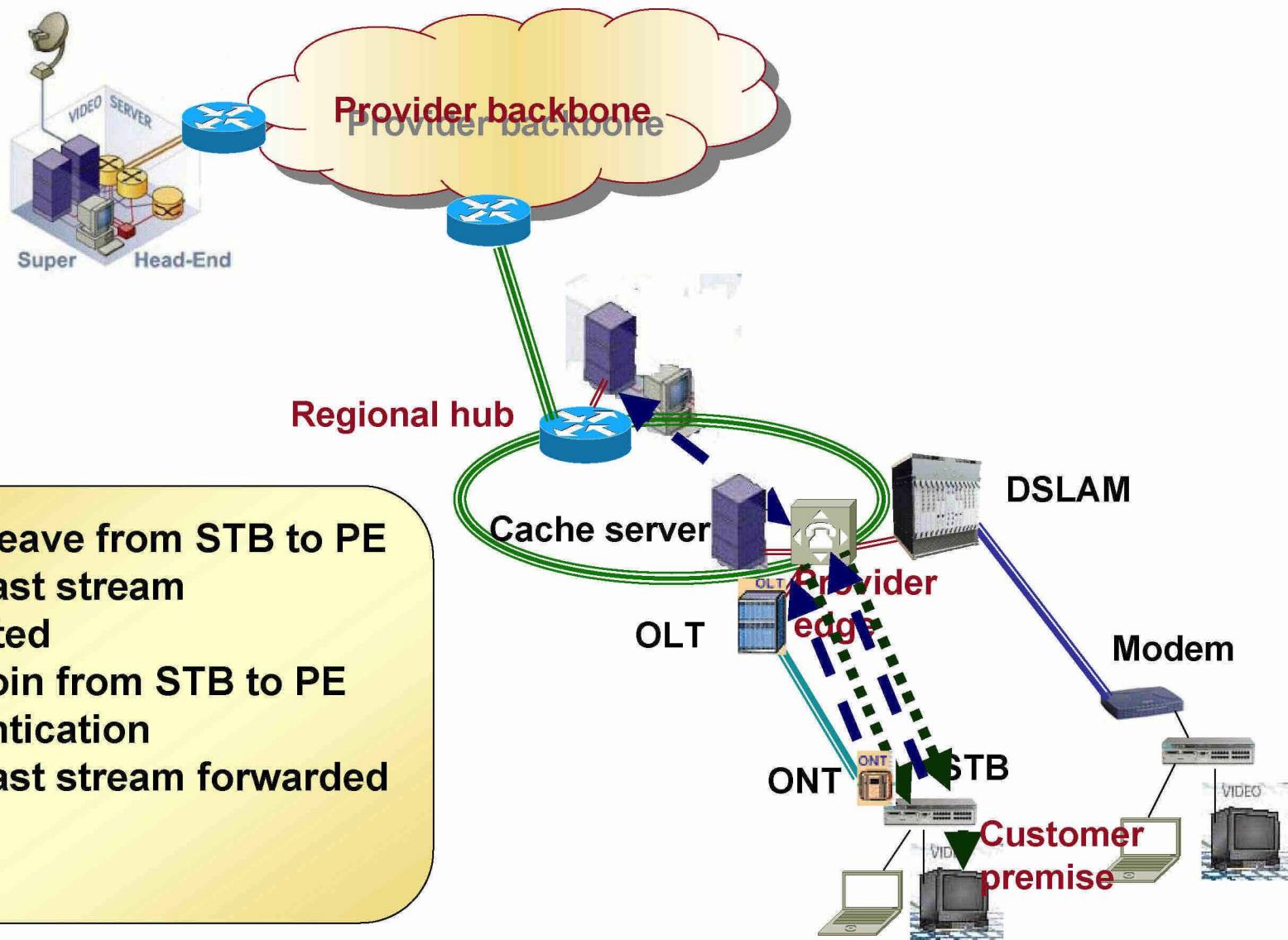
- Subscriber purchase of package
- Subscriber provisioning
- STB provisioning
- AAA provisioning at PE

Step 3: Customer choosing broadcast channel

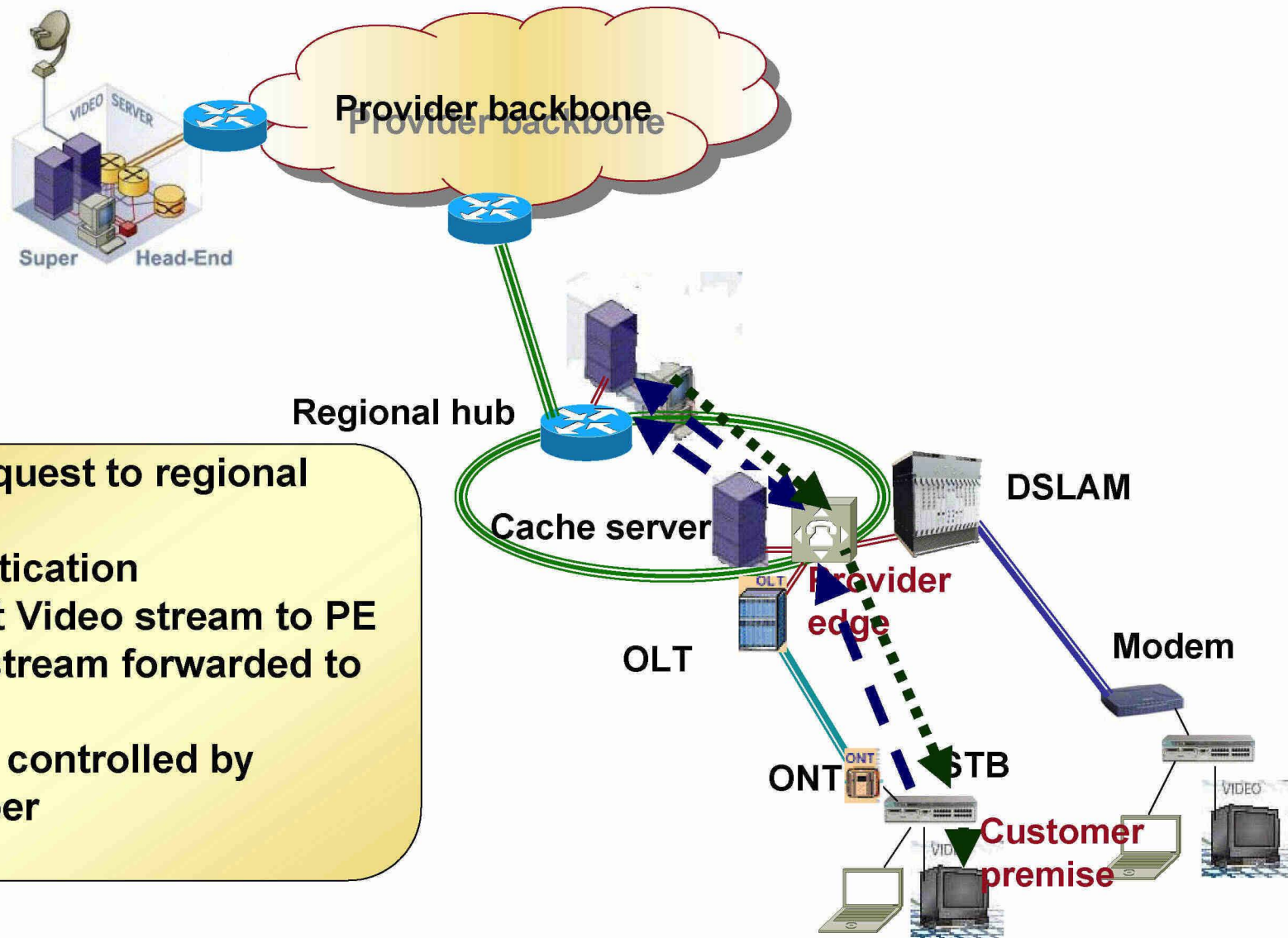


- IGMP join from STB to PE
- Authentication
- Multicast stream forwarded to STB

Step 4: Customer changes broadcast channel



Step 5: Customer opts for VoD service



- VoD request to regional hub
- Authentication
- Unicast Video stream to PE
- Video stream forwarded to STB
- Stream controlled by subscriber



Deployment case study





Case study: Now Broadband TV from PCCW

- Incumbent operator in Hongkong
- Pioneer in video based services (started in 2003)
- Network details
 - Headend equipment from TUT & Tandberg (SDTV/MPEG2)
 - Headend equipment from Tandberg (HDTV/MPEG4)
 - Edge routers from Riverstone previously, now Juniper E-series broadband service routers with SDX Service Deployment System
 - Core routers from Cisco
 - DSLAM from NEC
 - STB from Yuxing
 - Entone's full suite of VoD/IPTV solutions including StreamLiner (NVR), Encoding Studio (content ingestion workflow), Armada (intelligent asset manager)
- Service details (a la carte)
 - VoD
 - Broadcast TV (Star, ESPN, specific local channels – over 50 channels)
 - Gaming
 - Video conferencing
- Minimum requirement of 6Mbps bandwidth per user
- Over 5,00,000 subscribers in Nov 2005

Note: This is based on data available on public websites



In conclusion





Technical challenges for delivery of IPTV

- Last mile access to customer
 - Stable Broadband connectivity of at least 5–6 mbps required
- AAA & security
 - Customer receives the program as per his requirement
 - Provider is able to differentiate & charge for each service
 - No unauthorised access to the service is possible
- Quality of Experience
 - Customer receives equal or better quality than alternative video transmission mechanisms like cable
 - Customer receives a newer and larger portfolio of services
- Peak usage problem
 - Channel zap time
- Network infrastructure
 - Network provider is able to incrementally add new infrastructure to address service delivery requirements



Thank You

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